Media Choice for Complex and Knowledge-Intensive Processes

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Abstract

In this paper we present a theoretical framework that focuses on examining the implications of the process characteristics of complexity and knowledge intensity on the media quality of communication. Communication quality is defined along the dimensions of interactiveness, richness, and precision. Using this three-dimensional construct of communication quality, we provide a classification schema for the common media types. This schema classifies media choices into eight groups of unique communication quality. The three-dimensional framework provides managers with an analytical tool to make decisions regarding the choice of media choice based on the communication quality needs of the processes. Our thesis is that managers should develop a communication infrastructure that is capable of providing appropriate communication supports to the various processes. In organizations where media choice decision making and process set up have followed a different pathway, the communication quality supported by the already installed communication technologies may differ that required by the process setup within the organizations. The framework presented in this paper can be used by managers as a diagnostic tool to identify the process-communication misfits for correctional measures.

1. Introduction

All organizations can be effectively broken down into a collection of processes [1]. These processes rarely exist in isolation. Each process either (i) needs informational input from other processes, (ii) exists to provide informational output that serves other processes, or (iii) in some cases serves as both sender and receiver of information as it interacts with other processes. Collectively these interdependent processes deliver the organization's output. This process view of organization is represented graphically in Figure 1.

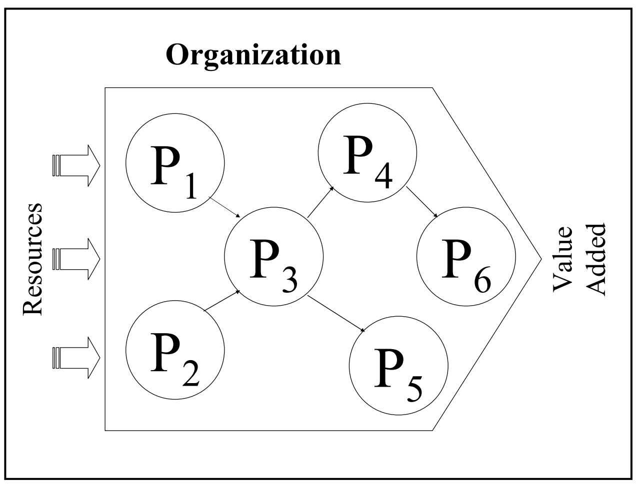

Figure 1 A process perspective of organization.

The search for effective means of managing these processes has become a central theme for business managers and researchers. This is especially evident in the level of focus that has been placed in issues such as the design of business processes and Business Process Reengineering (BPR). This search for the most effective means of structuring business processes raises the issue of 'what basic technology support do these processes need to become truly efficient and effective?'

Communication technology plays an integral role in process management. Prior research (e.g. [1, 2]) identify the necessity of adopting effective information and communication technology (ICT) for supply chain management. Research in other areas such as customer relation management (CRM) and enterprise resource planning (ERP) is also showing the importance of communication technologies for effective process management. The fact is, irrespective of the specific mission of the organization or business unit, information and communication technologies are emerging as a necessary factor for business success.

This need for effective information and communication technologies in process management leads to the question: "How do we proceed in choosing technologies to support our business processes?" We posit that characteristics of a process, such as its processing nature and how it is set up and organized to work with other processes, have a strong implication on what communication methods to be used in order to provide the required quality of communication to support the optimal operation of that process. Appropriate choice of communication technology leads to efficient and effective coordination within and between groups supporting business processes. Conversely, in cases where the communication technologies are not properly matched with the needs of the business processes, the quality of coordination activities suffers and process parameters/measures are not adequately met.

The primary objective of this current study is to present an analytical framework that delineates the associations between an identified set of critical process characteristics and the quality of communications required to provide an optimal support for the process's operations. In organizations where media choice decision making and process set up have followed a different pathway, the communication media quality supported by the already installed communication technologies may possibly different from that required by the process setup within the organizations. Such difference is a misfit. The analytical framework we present in this paper should facilitate a systematic detection of such misfits that may exist in an organization; hence, facilitating the management in formulating remedial measures. Furthermore, an analytic framework for diagnosing misfits in media quality should provide a base for future studies on performance consequences resulted from mis-deployment of communication technologies. Our research framework is graphically represented in Figure 2.

In the following paragraphs, we shall first address the process qualities that influence communication needs, followed by a discussion on the different dimensions in media quality. We then present a classification of the major media choices before addressing the issue regarding the gap in communication needs created by inappropriate choice of media. We also provide a discussion on the implication and the conclusion of the study.

2. Business Processes

Business processes collaborate to form an intertwined structure. The structure of processes has to be orchestrated if it is to achieve the organizational goal of adding value to the input resources. Each process in the structure has to comply with the restraints imposed by the various inter-process dependencies having information as an operating medium. Within the context of communication method selection, we focus only on the data and information processing activities of each process. In that sense, a process either shares information required as parameters or contributes to the creation of information that may be taken by another as input or end products. A process can be characterized in terms of process complexity and knowledge intensity.

2.1. Process Complexity

Process complexity is partly determined by the number of tasks included in that process, and partly by the inter-dependency it has between itself and other processes. Dependency arises in the situation where resources are to be shared by multiple activities [3]. By resources, we are referring to information resources within the context of information processing. For example, the process of shipment is set off only when the confirmation of successful payment collection is received from a web-order scenario. In that example, the payment confirmation is the resource, which is a piece of information, shared by two processes. Prior studies (e.g. [3-5]) have identified three fundamental types of dependencies: Fit, share, and flow. A 'fit' dependency arises when two processes contribute to the creation of a designated resource such as P1 and P2 in Figure 1 are required to create the output. Although the resource created by P1 and P2 is then fed into P3 as input, that input/output relationship is not part of the 'fit' dependency. Indeed; it constitutes another type of dependency, which Malone [3] refers as 'flow'. A 'flow' dependency arises when the output of a process is taken as input of another process such as P3 creates the resource that is taken as input by P4 in Figure 1. The third type of dependency, the 'share' dependency, arises when two processes share a designated resource such as P4 and P5 in Figure 1 share the resource created by P3.

Each of the three types of dependencies has different implications on information requirements for its coordination. In a 'fit' dependency, the interdependency between the participating processes is relatively not as strong. The performance of an involved process does not require the successful performance of the other involved process as a precondition. Nor does the performance quality of the involved processes have any thing to do with that of another. The same situation applies to the 'share' dependency type. In a 'flow' dependency; however, the processes engaged are much more tightly coupled in terms of information sharing. Since the coordination of each flow dependency requires at least three different aspects of it to be considered: Prerequisite, accessibility, and usability [3, 5]. Prerequisite is the precondition required by the process located at the lower stream of the 'flow' that is to be satisfied by the successful performance of other engaged process at the upper stream. Accessibility refers to the timing of such prerequisite to be obtained. Usability refers to the quality of the performance of the process at the upper stream of the flow. Each of these aspects will generate not only information processing needs, but also, frequently, in a more restrictive manner than the other two types of dependencies.

The temporal aspect of the performance of the processes is another important consideration in determining the process complexity. For example, processes P1, P2, and P3 are engaged in a snare of dependency relationships: P1 and P2 in a 'fit' dependency, while the three of them in a 'flow'. If the satisfaction of the prerequisite of the 'flow' required not only the successful performance of P1 and P2; but also that their performance need to be complete simultaneously; the interdependency among the three is much more intense than if the temporal aspect is not stringently designated. For example, in a corporate investment decision that involves a multi-million investment item, the analysis of the investment item and that of the cost and availability of the funding can be seen as having a 'fit' dependency. In order for the analysis results to be useful, they have to be done in a timely manner.

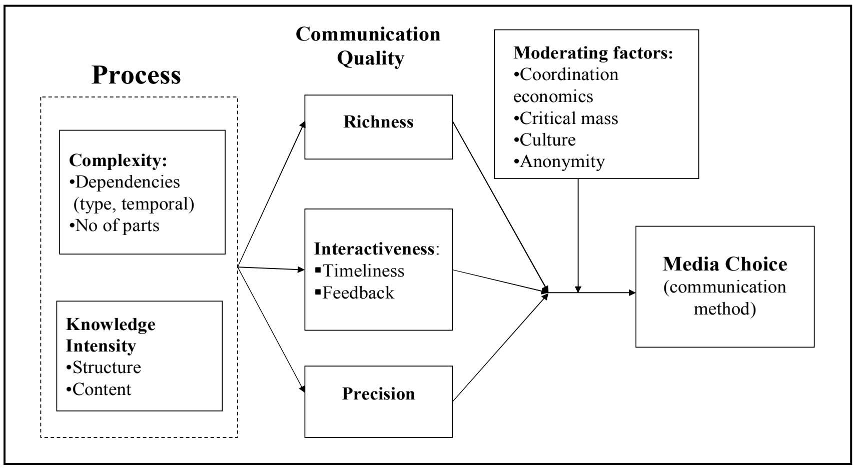

Figure 2 A prescriptive model illustrating the implications of process variables on media choice.

2.2. Knowledge Intensity

We identify two types of knowledge within the context of process: Knowledge as contents that pass through the process, and the knowledge about the process. In the example of an accounting information system, the financial information to be reported is being the content handled by an accounting process. Knowledge about a process includes knowledge at the task level and that at the process level. Knowledge at the task level is multi-faceted [6, 7]. It includes knowledge about the individual task goals and their associated procedures; where to acquire further information for continuing with the process or the task. Therefore, the number of tasks in a given process has a direct implication on its knowledge intensity. The higher the number of tasks within a process, the more knowledge intensive is the process. Knowledge at the process level includes the knowledge about the sequencing of these tasks within the process, its business goals, and the technical constraints imposed on a given process (indeed on the individual process tasks) by its implementation method.

The coordination of the dependency between two processes can be made easier by minimizing the requirements of knowledge about a process (both the content knowledge and that about the process) that another must acquire in order for the two to work together. Reducing the amount of content knowledge to be required for a process to be functional makes that process more self containing and easier to provide its service to a wider range of processes; hence, less interdependency exists between itself and any other one process. This can be exemplified by the traditional file-based processing technology and a modern database operating environment. In a typical file-based processing system, all its input and output files are usually defined around the processes. Such self-containing package provides a relatively independent environment compared to a database scenario in which interdependency management is typically a most challenging task.

While a given process may still be knowledge intensive, the knowledge required for another process to work with that knowledge intensive process can be mitigated by setting up a well defined process interface. An example of managing the issue arising in inter-process knowledge requirements is the use of information hiding and function interface in software engineering.

3. Media Quality in Communication

Prior works on information/media richness have twined the features of representation and interactiveness. Daft and Lengel [8] and Steinfield and Fulk [9] have taken media richness as a linear construct starting with lean medium written data and progressing to richer media such as telephone and face-to-face. Leaner medium are low on speed of feedback, types of channels used, personalness of source, and richness of language carried. Conversely, richer medium are high on all four variables. Existing technologies supported this theory very well. This model was extremely effective at a point when medium such as face-to-face and telephone fulfilled the role of being highly interactive and addition to adding the personal touch and carrying richer information content.

Recent developments in technology have reduced the effectiveness of this one-dimensional variable. Technologies such as written documents and email, positioned at the lean end of the continuum, for its single channel and slow feedback have made large strides over the last five years. Email now supports voice and video and response capability are limitless. Newer technologies are also emerging that cannot find a place in the one dimensional model. Instant messaging and other collaborative technologies such as NetMeeting have emerged with high speed of feedback, multiple communication channels but lacking the personal touch.

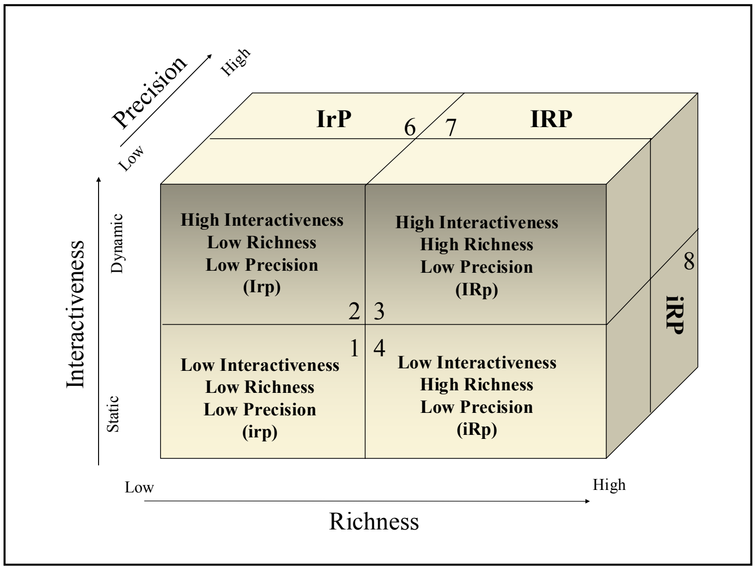

Figure 3 The dimensions of *Interactiveness*, *Richness*, and *Precision* underly media quality.

We posit that communication medium needs to be studied as a multi-dimensional construct. Three dimensions underlying the construct of communication media quality are identified: (a) The richness of the communication medium, (b) degree of interactiveness supported by the communication medium, and (c) the ability to support high level of precision in data representation. Figure 3 graphically depicts these three dimensions. Each of these dimensions is viewed as a dichotomous scale and intertwines with the other two to form eight enumerated quadrants, each indicating a unique media quality in communication. A given communication method, for example streaming media – widely used on the web to broadcast taped seminars and training sessions, provides high degree of richness but is low on interactivity. A viewer is able is experience most of the values of the original seminar but lacks the ability to communicate with the presenters and other attendees. Further, a team member needing information form his/her colleagues may find that the medium that brings higher degree of interactiveness, for example, does not also bring with it great measure of precision in data represented. Colleagues using telephone as a means of communicating often ask each other to send the details through another channel that supports written documents.

3.1. Richness

Media richness measures the number of channels available for the simultaneous transmission of data in communication notwithstanding the varying degree of feedback supported by the communication media and difference in the measure of personalness of each media. It therefore can be used as a measure for the depth/intensity of the data represented in these channels. The required level of media richness is a function of the multiplicity of information stimuli, temporal criterion of processing such stimuli, and the depth/intensity of the stimuli. Face to face, video conferencing, streaming video, computer conferencing and online/steaming presentations are all examples of very rich communication channels. The support visual information – allowing users to process gestures and body language along with voice and alpha numeric data.

3.2. Interactiveness

Interactiveness is a measure of the communication medium's ability to support level of contact needed by group members. Research on teamwork shows that communication technologies play an important role in bridging the gap between group members that are separated by space and/or time [3]. Higher degree of interactivity serves bridges this gap allowing dispersed team members to work more efficiently and effectively. In our model, we identify two underlying dimensions of interactiveness: (a) Whether feedback is allowed, and (b) how timely the feedback can reach its targeted recipient.

The type of inter-process dependence dictates that whether and how users share information. This need for information sharing demands timeliness of information transfer between participants and speed of feedback. Timeliness is an essential factor in information quality [10-12], and information quality is essential for effective process management. Note that the necessity for feedback may also arise in situation where no dependency is involved. Feedback is needed if the process includes mechanism for self adjustments. An example is that the thermostat is used as the mechanism to continuously detect for the presence of a preset temperature condition. Highly interactive or dynamic technologies support immediate/timely feedback. Among these are document conference conferencing and instant messaging. Less interactive technologies such as written documents and fax do not support immediate feedback.

3.3. Precision

Accuracy is a necessary element of information quality [12]. As such all processes demands accuracy built into the information content. In addition to accuracy, process dependencies often dictate high degree of precision in the representation of the information being shared. An engineering team working on the design of sensitive machinery may find video information on the work space in which the machine will function and operation of similar equipment at other sites to be very valuable. While the accuracy of the video file is not in question, the data is not represented in a way that accommodates the level of precision needed to support design. Technical drawings, detailing the specifications of the machinery and the physical layout of the rooms provide the degree of precision needed to execute the project. While richer media such as face to face are very effective at conveying the context of the situation on hand and at conveying accuracy, they often fail to address precision. Traditional leaner medium such as written/printed work, email (with attachments) and shared databases are extremely efficient at conveying the level of precision needed to perform more technical jobs.

4. Process Factors and Media Quality

Based on our discussions on communication quality, media types commonly available in organizations can be classified along the three-dimensions into the eight quadrants of the model for media quality (Figure 3). This classification is summarized in Table 1. Note that the classification is not meant to be exhaustive and there are quadrants that may have very few or none instances indicating a need to develop and/or identify communication technologies that are suitable to support the required type media quality.

Table 1 Sample media types classified into the eight quadrants of community qualification.

Quadrant/Media Quality Type	**Communication Technology Type (Media Choice)**
irp: Low Interactiveness; Low Richness; Low Precision	Fax
Irp: High Interactiveness; Low Richness; Low Precision	Email, Instant messaging , White boards
IRp: High Interactiveness, High Richness, Low Precision	Video conferencing, Teleconferencing, Telephone calls
iRp: Low Interactiveness, High Richness, Low Precision	Streaming video, Streaming audio, Streaming presentations
irP: Low Interactiveness, Low Richness, High Precision	Written documents, File transfer, Web pages, Shared database
IrP: High Interactiveness; Low Richness; High Precision	Electronic Meeting Systems (EMS), Document conferencing, Shared document
IRP: High Interactiveness; High Richness; High Precision	Face-to-face, Computer conferencing, Information Sharing (e.g. Lotus Notes)
iRP: Low Interactiveness; High Richness; High Precision	…

Process coordination requires information stimuli. These information stimuli include information about the required quality of shared resources in a dependency, the timing that such resources should be available, and whether such resources are available. These information stimuli have implications on the performance of all the processes engaged in a dependency relationship. Malone [3] addressed the importance of coordination for individual or group members working on activities with share dependencies. It is not enough to simply move work back and forth from members in a shared project. Instead, technology should be used to support cooperative nature of process operation. In order for the right kind of information stimuli to be communicated at the right time to the right process, appropriate media quality needs to be in place to support the information flow.

4.1. Implications of Process Complexity on Media Quality

We have discussed in the prior paragraphs the information processing implications of the two process factors, complexity and knowledge intensity. For complexity, the main focus has been on the interdepency a process has with another process. Process interdependency can be examined in terms of coordination. Among the three kinds of coordination, 'flow' is the one that has a higher demand for specific information (i.e. the prerequisite, accessibility, and usability aspects). The other two types of coordination, on the other hand, do not usually have as stringent information requirements as 'flow'. For example, the prerequisite aspect is frequently not a necessity to be considered. In our analysis, we do not see particular reasons for 'fit' to be distinctively different from 'share' in terms of needs for information specificity. As such, the media requirements for richness and precision regarding information needs for operation and coordination are more critical to 'flow' than to the other coordination types. Technologies in the Quadrant 7 and/or 8 in Figure 3 are the types that indicate attributes of such media quality. The horizontal axis of the matrix in Figure 5 represents the grouping of the three coordination types with 'fit' and 'share' on the left-hand-side representing a relatively less requirement of information precision higher tolerance for 'noises' that typically exist in a richer media choice. While 'flow' on the right-hand-side generally requires higher level of precision and is less tolerant for 'noises'. The vertical scale, Temporal Immediacy, in Figure 5 on the other hand indicates the relationship it has with the media quality of interactiveness.

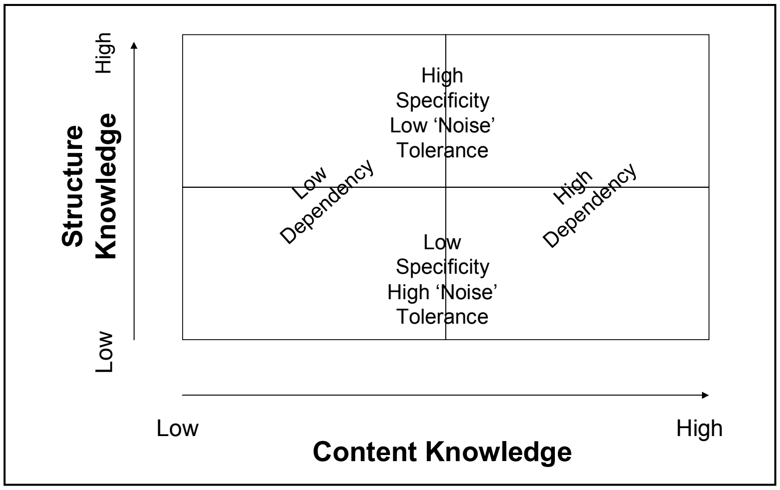

Figure 4 A classificatory schema for identifying communication needs based on process knowledge intensity.

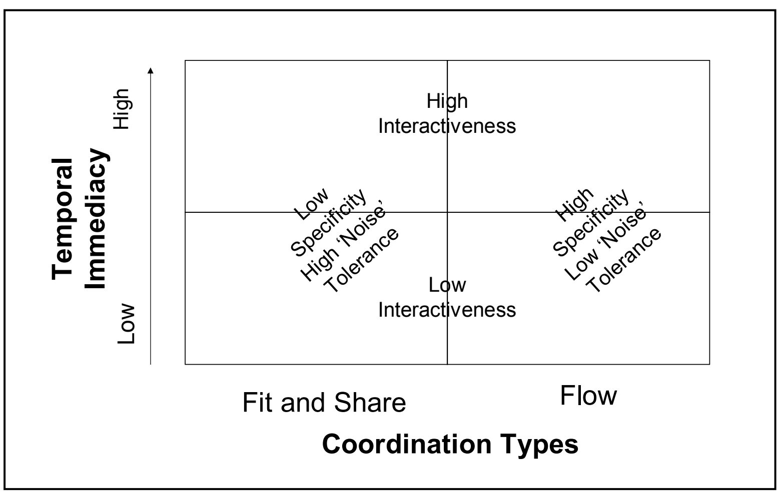

Figure 5 A classificatory schema for identifying communication needs based on coordination requirements.

4.2. Implications of Knowledge Intensity on Media Quality

Knowledge intensity of a process, based on the foregoing discussions, can be seen as comprising two dimensions: The content knowledge that passes through the process and subject to conversion by the process, and structural knowledge about the set up of the process. The level of content knowledge required by a process is directly related to the level of interdependency between processes; the higher the amount of content knowledge required by a process; the richer the media type is required to materialize the communication needs of the processes. While the level of structural knowledge available about a process contributes to the reduction of process equivocality, it requires a corresponding level of precision in the communication. These two dimensions of knowledge intensity and their implications on media quality are sketched in Figure 4.

5. Effect from Moderating Factors

Our analysis of the relationship between the desired media quality (Qr) and Media choice (M) reveals that in many cases several media types may be available to meets the needs of a specific user group. Moderating factors dictate the final choice of media for a given users group. A group requiring very rich and very interactive media, for example, will find that both face-to-face and video conferencing satisfies their needs. Physical distance separating the group members may dictate that video conferencing becomes the communication media of choice. This substitutable nature of communication technologies presents a degree of flexibility for managers. Managers are able to identify primary versus secondary/backup communication channels.

Prior research has found that factors such as culture and the anomity issue have a moderating influence on the way groups utilize technology [2, 13]. Moderating factors exert influences on managers with respect to which technology should become the primary communication media for a given group or process. Such influences may lead some groups to choose media that for example cater to more 'personal touch'. An individual may choose to take on large traveling costs to accommodate face-to-face travel while computer conferencing would have gotten the job done just as efficiently and effectively. Other moderating factors include such as the perceived costs and benefits (i.e. the coordination economic factor) associating with a particular media choice.

Moderating factors may influence a group to utilize a secondary technology rather than using the communication media that provides the best fit with their informational needs. Distant educators have long favored the richest media (video conferencing) as they strive to simulate the classroom experience. Video conferencing clearly provides level of richness and interactivity that approaches face-to-face communication. Unavailability of the necessary infrastructure to support video conferencing has led many educators to use less rich media such as web-based collaboration or less interactive technologies such as streaming audio and video. In the final analysis, the interaction between the media quality needed and these moderating factors will yield a short list of communication media serves the coordination needs of a given user group.

6. Gap in Media quality and Managerial Implications

The typology for communication media establish in Table 1 implies a measure of substitution is available to process managers as technology choices are made. Unavailability of the primary technology may lead to the use of a technology that provides lower media quality. For example, a telephone may replace video conferencing. Both provide modest to high levels of richness and very high levels of interactiveness. A telephone conversation does not provide the visual cues and body language provided by video conferencing. In cases where these traits are critical to the process on hand, the media quality may be compromised at the cost of process performance.

Substitution of technology often occurs outside the grids in Table 1. If an individual working on process Pn

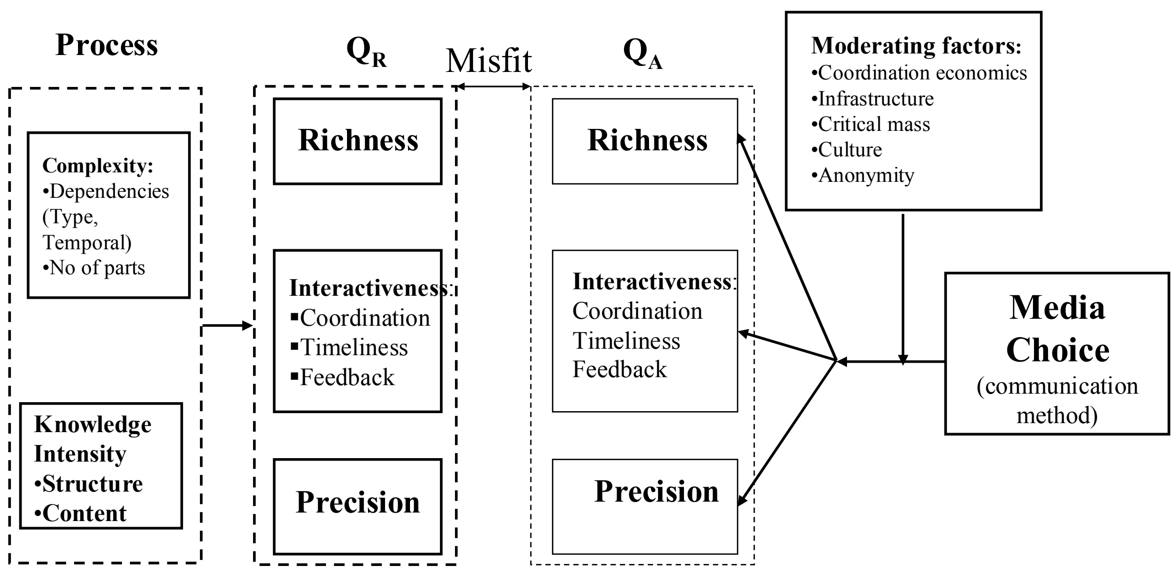

Figure 6 Misfit between the media quality required and that available from the already installed communication technologies.

cannot obtain information from another working on a dependent/preceding process Pn-1 in a dynamic manner, such as using the telephones, s/he may choose to write a note or send an email instead. This use of secondary media introduces more severe reduction in media quality. Actual media quality (QA) being delivered becomes further jeopardized. Whereas process Pn implies that it needs media quality QR the available technology may only be able to deliver a lower media quality. The difference in media quality is represented as a quality gap QR-QA. In an ideal world QR should match with QA and leave no quality gap. In reality QA is often mismatched by QR and a non-zero quality gap hence created. Figure 6 graphically describes the misfit existing between QR and QA.

Media quality gap becomes especially significant when the substitute technology is from a different quadrant than the ideal technology. For example, the loss of media quality is much greater if video conferencing is substituted by written (mailed) documents (moving from quadrant 3 to 5) than if it is substituted by teleconferencing (remaining in quadrant 3). Substitution within quadrant implies similar levels of richness, precision and interactiveness – hence a smaller quality gap. Substitution outside the quadrant implies much larger changes in richness, precision and/or interactiveness – hence the quality gap is larger. Quality gap is often increased further by failure on the part of employees to effectively utilize all available technology. Many organizations are making web conferencing available to their employees. This provides significant measure of richness plus very high measure of interactiveness. Employees failing to utilize such technologies for business processes that require richness and interactiveness as measure of media quality would have further increased the quality gap. Media quality may therefore be analyzed in three stages:

1. Assessing the required media quality (QR) ideally needed to satisfy the communication and coordination needs within interdependent processes,

2. Assessing the available media quality (QA) as determined by the technologies provided to the users or groups, and

3. Evaluating the media quality delivered (QU) as a result of the actual usage of technology by the users or groups.

Project failure and the factors influencing the probability of failure have intrigued researchers and business managers for a long time. Software developers report failure rates of the magnitude of 90 percent or higher. While some of these projects actually 'worked' in the final analysis, they are still deemed as failure for several reasons. These include lateness, lower than anticipated quality, delivery of partial functionality and projects coming in significantly over the budgeted costs. While many of these measures have not been formally applied the broader array of businesses, the similarities are clearly existent. A high percentage of businesses processes are failing to meet quality expectations on the run, project lateness continue to plague any business units and inefficiencies and the resulting use of overtime often lead projects coming in over the budgeted costs.

Our thesis is that while process characteristics should inform the logical choice of communication method (Cr), actual communication method (Ca) is frequently determined by 'what is already there'. When process design and the technological infrastructure have taken a different path to develop, the installed technologies may be substantially different from what is actually required. This misfit results in a gap in communication media quality. We posit that media quality gap is a contributor to these measures of project failure. Tabata and Mitsumori [14] identifies the problems caused by poor coordination in projects. Large media quality gap is a significant contributor to coordination problem between dependent sub processes. As such media quality and media choice demands some attention for process managers. Our analysis identified two contributors to media quality gap. The first contributor, the difference between the desired media quality and the available technology, is often influenced largely by affordability of the technologies. Business managers will need to address very tough budgeting issues. The second issue, the actual usage level of technology, needs to be addressed through employee development and training.

IT Infrastructure should provide support for the media quality required by the various processes. Our theoretical framework can be used as tool to analyze the media quality required. The two constructs in the model further provides an internal structure for the model.

7. Conclusion

In this paper we present a theoretical framework that models the relationship between critical process characteristics and the communication media quality. The framework focuses on examining the implications of the process characteristics of complexity and knowledge intensity on the media quality of communication. Media quality is defined along the dimensions of interactiveness, richness, and precision. Using this three-dimensional construct of media quality, we provide a classification of various media types into eight classes of unique media quality. The framework provides managers with an analytical tool to make decisions regarding the choice of communication methodology based on the media quality needs of the processes. Our thesis is that managers should develop a communication infrastructure that is capable of providing appropriate communication supports to the various processes. In organizations where media choice decision making and process set up have followed a different pathway, the media quality supported by the already installed communication technologies may differ that required by the process setup within the organizations. The framework presented in this paper can be used by managers as a diagnostic tool to identify the process-communication misfits for correctional measures.

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